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AMENDMENTS TO THE SPECIFICATION

Please replace the paragraphs on page 1, line 3 (numbered line 1) – page 5, line 30 with the following:

BACKGROUND

The invention relates to a method of detecting a malfunction during a displacement of an element by a drive system~~, in which method a processor determines a difference between a predetermined desired value and an actual value at regular intervals during the displacement of the element~~. The invention further relates to a device suitable for carrying out such a method.

~~Such a method is known per se from~~ One known method, which is set forth in EP-B1-0 365 681, detects a collision~~. A collision~~ between machine parts driven by servomotors and an object ~~can be detected by means of the method described therein~~. A processor calculates the derivative of the speed of the servomotor during a preceding period and subtracts it from the derivative of the speed of the servomotor over the present period. The absolute value of the calculated difference is taken, and this is compared by the processor with a given reference value. If the value is greater than the given reference value, this is interpreted as an indication that there is a collision.

~~Such a~~ The method of EP-B1-0 365 681 has the disadvantage that the detection of a collision takes a comparatively ~~much~~ great amount of time. The great amount of time ~~because~~ is caused by the minimum time required for detecting the collision, which is equal to the length of the chosen time ~~period, with the result that the~~ period. As a result, a malfunction may already have occurred at the beginning of ~~the measured~~ a period currently being measured.

SUMMARY

~~The invention has for its object~~ An object of the present invention is to provide a method wherein the time required for detecting a malfunction is ~~comparatively short~~ shorter than that of the prior art. This object is achieved ~~in the method~~ according to ~~the invention in that~~ a method embodiment of the present invention. As compared to the prior art, the processor of this method further determines a derivative of the difference at regular ~~intervals, said~~ intervals; the difference and its derivative both ~~fluctuating~~ fluctuate around an equilibrium ~~value, whereupon~~ value. Subsequently, only the values at one side of the equilibrium value of the both the difference and the derivative are ~~taken, the~~ sampled. The

sampled values of the difference are multiplied by the sampled values ~~value~~ of the ~~derivative, the~~ derivative. The outcome of the multiplication is compared with a reference value by the ~~processor, and a~~ processor. A malfunction in the displacement of the element is detected if the outcome of the multiplication is higher than the reference value.

The multiplication of the value of the derivative of the difference by the value of the difference at a single side of the equilibrium value generates a curve in time ~~which~~ that, at a time of a malfunction, has a slope that is ~~comparatively~~ steeper ~~slope~~ (also denoted comparatively great directional coefficient) ~~in the case of a malfunction~~ than the curve of the value of the derivative and/or the curve of the difference value at that time. As a result, the multiplication curve will rise comparatively quickly in the case of a ~~malfunction, so that the~~ malfunction and, therefore, the reference value ~~is reached comparatively~~ will be reached more quickly, thereby more readily detecting that a malfunction has occurred. ~~and a malfunction can be ascertained and detected.~~

~~An embodiment~~ According to an embodiment of the method according to the ~~invention is characterized in that~~ present invention, the chosen side of the equilibrium ~~value is~~ value may be dependent on the direction in which the element is displaced. If the element has a certain speed in a certain direction, the speed in said direction will drop below the desired value the moment a collision occurs. This information is relevant for detecting a collision. The information that the speed of the element is higher than the desired ~~value is~~ value may be of no importance in such a case and may, therefore, accordingly be ~~set for~~ set to zero.

~~Another~~ According to another embodiment of the method according to the ~~invention is characterized in that~~ present invention, the signals of the ~~derivative are~~ derivative may be filtered. An advantage of such filtering ~~this~~ is that exclusively those signals ~~remain owing to the signal filtering which~~ that are relevant for making a malfunction detection ~~possible~~ remain.

~~A further~~ According to another embodiment of the method according to the ~~invention is characterized in that~~ present invention, the predetermined desired value ~~represents~~ may represent the desired position of the displaceable element, while the actual value ~~represents~~ may represent the actual position of the element. An advantage of such a method is that the element can be accurately displaced into a desired position, while a malfunction during the displacement, such as a collision, is detected comparatively quickly.

~~It is a further object of the invention~~ Another object of the present invention is to provide a device by means of which a malfunction in a drive system for the displacement of

an element can be detected comparatively quickly. This ~~object is~~ object may be achieved by an embodiment of a device ~~in the device~~ according to the ~~invention in that the~~ invention. The device is provided with an element that is displaceable by means of a drive system and with a processor provided with means for comparing a desired value with an actual value, means for determining a derivative, means for determining values lying at one side of an equilibrium value, multiplication means, and means for comparing the outcome of a multiplication with a reference value. A malfunction, such as a collision, can be detected comparatively quickly by means of ~~such a device, as was described further above~~ a device that perform one or more of the method embodiments previously discussed.

~~The invention will be explained in more detail below with reference to the accompanying drawings, in which:~~

It is to be understood that both the foregoing general description and the following detailed description are exemplary and explanatory only, and are not restrictive of the invention as claimed.

BRIEF DESCRIPTION OF THE DRAWINGS

These and other features, aspects, and advantages of the present invention will become apparent from the following description, appended claims, and the accompanying exemplary embodiments shown in the drawings, which are briefly described below.

Fig. 1 shows a component placement device according to an embodiment of the present invention;

Fig. 2 shows a control circuit of the device shown in Fig. 1, in which a feedback between the processor and the drive system is shown;

Fig. 3 is a graph representing a difference between a desired value and an actual value in time, and a derivative thereof;

Fig. 4 is a graph ~~showing curves representing~~ of the difference and the derivative of the difference shown in Fig. 3 having ~~after~~ the positive ~~part has been set for~~ parts thereof set to zero; and

Fig. 5 ~~shows the~~ is a graph of a multiplication of the curves of Fig. 4 in addition to the curves of~~, now containing a further curve corresponding to the multiplication of the curves shown in~~ Fig. 4.

DETAILED DESCRIPTION

Corresponding components have been given the same reference numerals in the Figures.

Fig. 1 shows a component placement device 1~~which~~ that is provided with a frame 2. Rails 3 are situated on the frame 2 at both sides. A guide 4 extends transversely to the rails 3 and is displaceable over the rails 3 by means of a drive system (not shown) in and opposite to the direction indicated by arrow P1. An arm 5 is provided on the guide 4, which arm is displaceable by means of a drive system over the guide 4 in and opposite to the direction indicated by arrow P2. The direction of arrow P2 is perpendicular to the direction of arrow P1. An imaging device 6 and a placement device 7 are fastened to the arm 5.

A transport device 8, by means of which substrates 9 are displaceable in the direction indicated by arrow P2, is present below the arm 5. Each substrate 9 is provided with at least one reference element 10. The component placement machine 1 is further provided with a component feeder device 11 from which components can be taken by the placement device 7. A further imaging device 12 is located on the frame 2.

Fig. 2 shows a control circuit 13 of a processor of a component placement device 1, diagrammatically showing a controller 14 by means of which a drive system 15 of the arm is controlled. The arm 5 will always be controlled such that the placement device 7 is displaced into a desired position. This desired position is applied to a difference determinator 16 via input element 17. The actual position of the placement device 7 realized by the controller 14 and the drive system 15 will also be applied to this difference determinator 16.

The set-up of the control~~circuit 16 discussed thus far~~ circuit 13 is conventionally known~~per se and will~~ and, therefore, will accordingly not be described in any more detail.

Fig. 3 shows a graph with two~~curves, curve A representing~~ curves. Curve A represents the difference between the desired position and the actual position of the placement device 7~~in time t,~~ versus time (t) while curve B is the derivative of curve A ~~in time~~ versus time. As is apparent from the graph,~~the curves~~ curves A and B vary around an equilibrium value 0. It is visible in the graph that a malfunction occurs in~~the curve~~ curve A at a moment t_v, such that the difference between the desired position and the actual position assumes a considerable negative value. Such a situation may arise, for example, if the placement device 7 is displaced in the direction indicated by arrow P1, which direction indicated by arrow P1 corresponds to the negative X-direction. ~~The curve~~ At time t_v, curve B, being the derivative of curve A, first shows a steep drop, whereupon it assumes a constant negative value. ~~The malfunction~~ By way of further example, the malfunction may be caused~~, for example,~~ by the~~fact that the~~ placement device~~7 during its displacement hits against~~ 7, during its displacement, hitting a component already provided on the substrate 9,~~with a~~ thereby resulting in a collision~~as a result~~.

The actual position of the placement device 7 will never be beyond the desired position in the direction indicated by arrow P1 in the case of a collision during the displacement of the placement device 7 in the direction of arrow P1. This means that the part of the curve for which the difference between the desired position and the actual position is positive may be disregarded. Accordingly, this value is ~~set for~~ set to zero in the controller 14 in accordance with ~~the method~~ a method embodiment according to the invention. The resultant curves A' and B' are shown in Fig. 4, which shows the curves A and B of Fig. 3, with the parts of the curves A and B situated above the equilibrium value 0 being reset to 0.

Fig. 5 shows the curves ~~A and B~~ A' and B' of Fig. 4 as well as a curve ~~C. The curve C~~ C, which is the multiplication of the curves ~~A and B. The curve~~ A' and B'. Curve C occasionally assumes positive values with a maximum amplitude R ~~which~~ that is considerably smaller than the amplitudes of the curves ~~A and B~~ A' and B' over the time period from to t_0 to t_v. This amplitude over the indicated time period t_0-t_v may serve as a reference value R for detecting a normal displacement.

From the moment t_v, onwards, ~~i.e. the~~ i.e., the moment the collision takes place, curve ~~the curve~~ C rises with a very steep gradient. As is visible in Fig. 5, shortly after time t_v, the accompanying ~~value~~ amplitude of curve C will be considerably higher than the amplitude of curve C in the time period t_0-t_v ~~a very short time after t_v already~~. The moment the reference value R is exceeded, which is the case comparatively soon after moment t_v ~~already, as described above, this~~ can ~~and will~~ be regarded as a signal that a collision has taken place. The arm 5 should now be stopped by means of the processor or be displaced in a direction opposed to that of arrow P1 so as to avoid damage to the placement device 7 and/or the substrate 9.

It is also possible to determine a higher-order derivative instead of the derivative of curve B. A higher-order derivative ~~is more~~ may be more accurate, but also ~~increases~~ may increase the required calculation time. Depending on the desired application, a compromise between accuracy and the desired calculation time ~~will have to~~ may be made.

~~The controller~~ If desired, the controller 14 may carry out a filtering function ~~during~~ while determining ~~of the~~ the derivative, ~~if so desired, so as to remove~~ thereby removing noise and other undesirable effects from the measured curve.

It is also possible to supply a desired and actual speed, force, or temperature to the difference determinator ~~16 instead~~ 16, instead of the desired and actual positions.

It will be obvious that the desired and actual positions of the placement device 7 processed in the control circuit 13 may relate to ~~the X as well as to the Y and Z~~ the Z as well as the X and Y directions.

It is also possible to apply the method according to the invention to a rotary ~~instead of a translatory displacement~~ displacement (i.e., along an arc) rather than the above-described linear displacement.

The graphs of Figs. 3 to 5 merely show an ~~example~~ embodiment of the present invention. In practice, the difference between the actual value and the desired ~~value will~~ value may fluctuate much more irregularly. In addition, although the transition caused by a disturbance of the derivative ~~is usually~~ may not be a stepped ~~one~~ function, ~~but has~~ it should have a comparatively great directional coefficient.

It is also possible to take a reference value of, for example, 2R instead of the reference value R.

It is also possible to multiply the difference by both the first and the second derivative, so that a malfunction can be detected even more quickly.

Given the disclosure of the present invention, one versed in the art would appreciate that there may be other embodiments and modifications within the scope and spirit of the invention. Accordingly, all modifications attainable by one versed in the art from the present disclosure within the scope and spirit of the present invention are to be included as further embodiments of the present invention. The scope of the present invention is to be defined as set forth in the following claims.